

UNIVERSITY OF FORT HARE

PHY113F

**EXAMINATIONS
MAY / JUNE 2025**

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Time: 3 HOURS

Subject: ELECTROSTATICS AND MAGNETISM

Marks: 100

This paper consists of 5 pages, including a cover page.

Internal Examiner
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Moderator
MS MAPANTSELA

Instructions

- Answer all three (3) questions
- Read the question more than once and write down your data.
- When solving problems, specify applicable definitions and draw clearly labeled diagrams.

$$v_{xf} = v_{xi} + a_x t, \quad v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i), \quad x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2,$$

$$x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})t, \quad \vec{F}_{12} = k_e \frac{q_1 q_2}{r_{12}^2} \hat{r}, \quad \vec{E} = \frac{\vec{F}}{q}, \quad \vec{E} = k_e \frac{q}{r^2} \hat{r}, \quad \vec{E} = k_e \sum_i \frac{q_i}{r_i^2} \hat{r}_i,$$

$$\vec{E} = k_e \int \frac{dq}{r^2} \hat{r}, \quad q = \pm Ne, \quad dq = \rho dV, \quad dq = \sigma dA, \quad dq = \lambda dl, \quad \rho = \frac{Q}{V}, \quad \sigma = \frac{Q}{A},$$

$$\lambda = \frac{Q}{l}, \quad \vec{a} = \frac{q\vec{E}}{m}, \quad \Phi_E = EA \cos \theta, \quad \Phi_E = \int_{\text{surface}} \vec{E} \cdot d\vec{A}, \quad \Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0},$$

$$A_{\text{sphere}} = 4\pi r^2, \quad V_{\text{sphere}} = \frac{4}{3}\pi r^3, \quad \vec{F} = q\vec{E}, \quad \Delta U = -q \int_A^B \vec{E} \cdot d\vec{s}, \quad \Delta U = -q \int_A^B \vec{E} \cdot d\vec{s},$$

$$\Delta V = \frac{\Delta U}{q}, \quad \Delta V = -\int_A^B \vec{E} \cdot d\vec{s}, \quad \Delta V = Ed, \quad V = k_e \frac{q}{r}, \quad V = k_e \sum_i \frac{q_i}{r_i}, \quad U = k_e \frac{q_1 q_2}{r_{12}},$$

$$U = k_e \sum_i \frac{qq_i}{r_i}, \quad E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}, \quad C = \frac{Q}{\Delta V}, \quad \sigma = \frac{Q}{A},$$

$$C = \frac{\epsilon_0 A}{d}, \quad Q_{\text{eq}} = Q_1 + Q_2, \quad C_{\text{eq}} = C_1 + C_2, \quad \frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2},$$

$$\Delta V_{\text{eq}} = \Delta V_1 + \Delta V_2, \quad W = U = \frac{Q^2}{2C} = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2, \quad U = \frac{1}{2}\epsilon_0 AdE^2,$$

$$u_E = \frac{1}{2}\epsilon_0 E^2, \quad R = \sqrt{R_x^2 + R_y^2 + R_z^2}, \quad I = \frac{\Delta Q}{\Delta t}, \quad J = \frac{I}{A} = nqv_d, \quad J = \sigma E, \quad R = \rho \frac{l}{A}$$

$$\rho = \rho_0 [1 + \alpha(T - T_0)]$$

Constants (PHY113F)

$$k_e = \frac{1}{4\pi\epsilon_0} \approx 9.0 \times 10^9 \text{ N}\cdot\text{m}^2 / \text{C}^2, \quad \epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 / \text{N}\cdot\text{m}^2, \quad g = 9.8 \text{ m/s}^2,$$

$$N_A = 6.02 \times 10^{23}$$

TABLE 23.1

Charge and Mass of the Electron, Proton, and Neutron

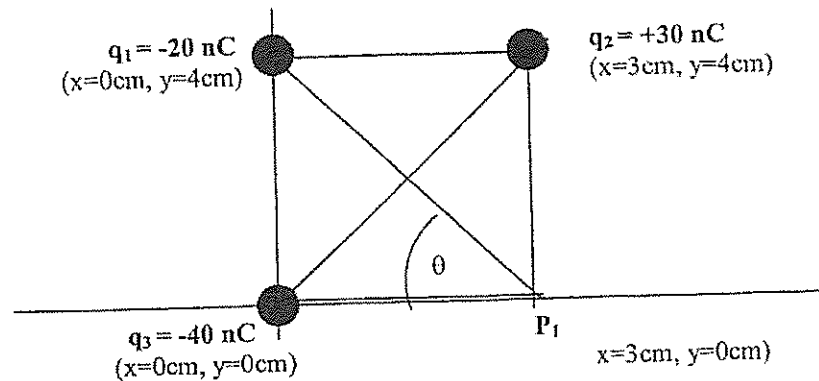
Particle	Charge (C)	Mass (kg)
Electron (e)	$-1.602\,176\,5 \times 10^{-19}$	$9.109\,4 \times 10^{-31}$
Proton (p)	$+1.602\,176\,5 \times 10^{-19}$	$1.672\,62 \times 10^{-27}$
Neutron (n)	0	$1.674\,93 \times 10^{-27}$

**Resistivities and Temperature Coefficients of Resistivity
for Various Materials**

Material	Resistivity ^a ($\Omega \cdot \text{m}$)	Temperature Coefficient ^b $\alpha [(\text{°C})^{-1}]$
Silver	1.59×10^{-8}	3.8×10^{-3}
Copper	1.7×10^{-8}	3.9×10^{-3}
Gold	2.44×10^{-8}	3.4×10^{-3}
Aluminum	2.82×10^{-8}	3.9×10^{-3}
Tungsten	5.6×10^{-8}	4.5×10^{-3}
Iron	10×10^{-8}	5.0×10^{-3}
Platinum	11×10^{-8}	3.92×10^{-3}
Lead	22×10^{-8}	3.9×10^{-3}
Nichrome ^c	1.50×10^{-6}	0.4×10^{-3}
Carbon	3.5×10^{-5}	-0.5×10^{-3}
Germanium	0.46	-48×10^{-3}
Silicon	640	-75×10^{-3}
Glass	10^{10} to 10^{14}	
Hard rubber	$\sim 10^{13}$	
Sulfur	10^{15}	
Quartz (fused)	75×10^{16}	

Question 1 (Coulomb's law, Electric Field, Electric Potential, and Potential Energy)

1.1. Two point charges are located in the xy plane as follows:



Charge $q_1 = -20 \text{ nC}$ is located at point $(x = 0 \text{ cm}, y = 4 \text{ cm})$, and a second charge, $q_2 = +30 \text{ nC}$, is at the end $(x = 3 \text{ cm}, y = 4 \text{ cm})$. A third charge $q_3 = -40 \text{ nC}$ is placed at the origin $(x = 0 \text{ cm}, y = 0 \text{ cm})$.

1.1.1. Calculate the Resultant Coulomb Force on charge $q_2 = +30 \text{ nC}$ due to the presence of q_1 and q_3 (both magnitude and direction). (10)

1.1.2. Draw a labeled vector diagram (WITHOUT CALCULATIONS) of the Electric Field at point P_1 . (3)

1.1.3. Calculate the Electric Field at point P_1 . (7)

1.1.4. CALCULATE the overall Potential Energy (ΔU) of the system of charges. (5)

1.1.5. CALCULATE the Electric Potential (V) at point P_1 . (5)

1.2. The potential difference between the accelerating plates of a television set is about 25 kV. If the plates are separated by 1.5 cm, estimate the magnitude of the uniform electric field between the plates. (3)

1.3. An electron is shot from one large metal plate toward a parallel plate. If the electron's initial speed $6.0 \times 10^6 \text{ m/s}$ and its speed just before it hits the second plate is $4.0 \times 10^6 \text{ m/s}$.

1.3.1. What is the potential difference between the plates? (5)

1.4 A particle of $q_1 = +4q$ at the origin of an x-axis and a particle of $q_2 = -q$. The distance between the charges is L . At what point can a proton be placed so that it is in equilibrium? Please show the diagram.

(10)

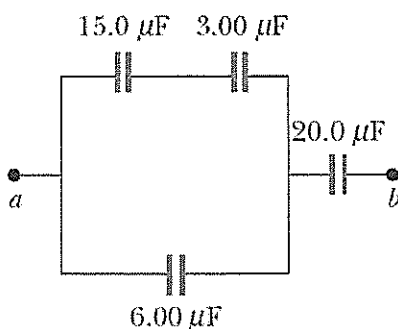
Question 2

(GAUSS' LAW AND CAPACITENCE)

2.1 Find the electric field outside and inside a hallow shell using gauss law and show the diagram.

(6)

2.2 Consider the combination of capacitors in the figure below.



2.2.1 Calculate the equivalent (or total) capacitance of the group.

(6)

2.2.2 Calculate the charge on each capacitor if $\Delta V_{ab} = 15.0 \text{ V}$.

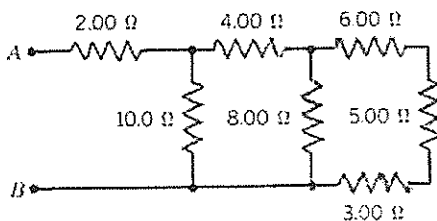
(10)

Question 3

(Direct Current in Circuits)

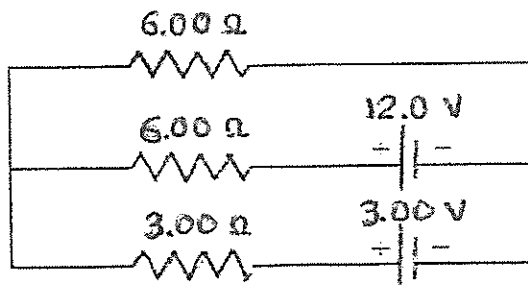
3.1. Find the equivalent resistance between points A and B in the drawing below.

(10)



3.2. For the circuit shown in the drawing below, find the current in the 3.00 Ω resistor and specify the direction of the current.

(10)



3.3 One end of an aluminum wire whose diameter is 2.5mm is welded to one end of a copper wire whose diameter is 1.8mm. The composite wire carries a steady current of 17mA. Determine the current density of both materials.

(5)

3.4 A wire of length $L= 2035$ m and diameter $d= 1.63$ mm carries a current of 1.24A. The wire dissipates electrical energy at the rate P of 48.5 mW. Of what is the wire made of?(5)